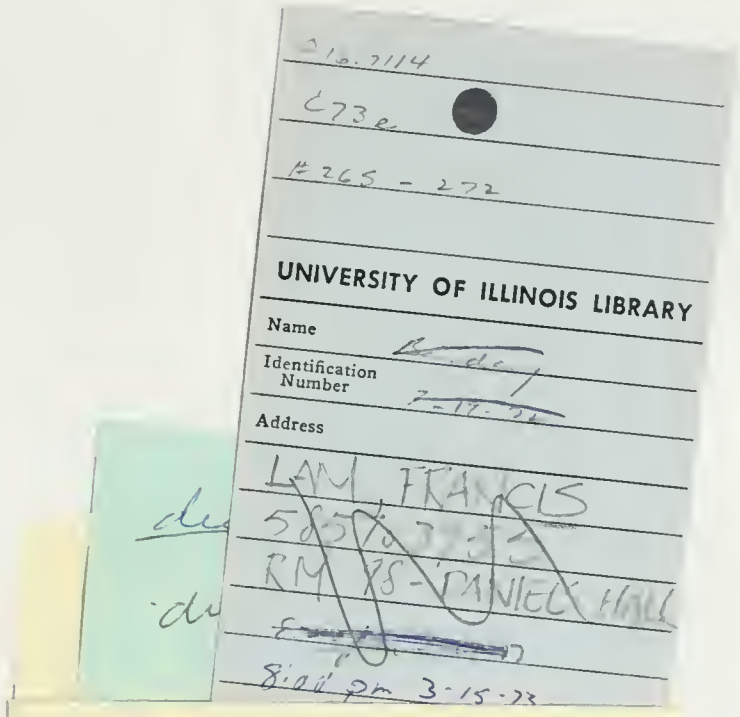
no. 7114
C73e
#265 - 272
UNIVERSITY OF ILLINOIS LIBRARY
Name
Identification Number
Address
LAM, FRANCIS
RM 18 - DANIEL HALL
8:00 pm 3-15-73

Council of Planning Librarians EXCHANGE BIBLIOGRAPHY

March 1972

271

APPLICATIONS OF MATHEMATICAL PROGRAMMING MODELS IN EDUCATIONAL PLANNING: An Overview and Selected Bibliography

James F. McNamara, Associate Professor
The Lila Acheson Wallace School of Community Service and Public Affairs, University of Oregon

Mrs. Mary Vance, Editor
Post Office Box 229
Monticello, Illinois 61856

APPLICATIONS OF MATHEMATICAL PROGRAMMING MODELS IN EDUCATIONAL PLANNING: AN OVERVIEW AND SELECTED BIBLIOGRAPHY

by

James F. McNamara, Associate Professor*
The Lila Acheson Wallace School of Community
Service and Public Affairs
University of Oregon

During the past few years there has been a rapid development of the field OPERATIONS RESEARCH or MANAGEMENT SCIENCE which should not be confused with the older tradition of SCIENTIFIC MANAGEMENT in the sense of time and motion studies. Management science models that express the organizational environment and its dynamics in mathematical relationships have been applied in the fields of business management, defense analysis, transportation logistics, and more recently in public sector and regional planning. Although the value of these techniques have been demonstrated in the areas listed above, administrators and planning specialists are just beginning to explore the feasibility of adapting these techniques as a means to improve educational planning and decision-making.

The research and bibliography reported here first began as a result of the need for developing an information base or a "state of the art" paper to plan some of the future research in Program 40: Procedures for Systems Planning, one of the five programs of the Center for the Advanced Study of Educational Administration. This program is designed to investigate the emerging trends outlined above and, more important, the direct utility of operations research and management science models that might be especially suited to the management of instructional programs and to the planning for instructional change in educational organizations.

An earlier version of this research has been used as a part of a presentation on mathematical programming models given at the American Educational Research Association conference presession on Operations Analysis Techniques in Educational Planning and Administration in New York City in February 1971. This five day presession was jointly funded by the National Science Foundation and the

---

*The author also holds the position of research associate in The Center for the Advanced Study of Educational Administration (CASEA) which is located on the University of Oregon campus. CASEA is a national research and development center funded by the U.S. Office of Education.

American Educational Research Association. This research was subsequently published by this author in the December 1971 issue of the Review of Educational Research under the title of "Mathematical Programming Models in Educational Planning."

The exchange bibliography is based on this article. The review and synthesis for many of the references included in the exchange bibliography can be found in the Review of Educational Research article. However, a number of new references are included here. They are grouped in three sections. The first section deals with the actual educational applications. The second with the related literature in educational planning and systems analysis. The last section includes a few selected general operations research publications that were found in many of the bibliographies of the applications. It also includes those recommended by planners as most useful in this modeling area. This last section will, no doubt, be of particular interest to professors who are responsible for teaching introductory or overview courses in administrative science, planning or operations research where the students come from a wide range of disciplines and have many interdisciplinary interests.

Some major conclusions based on the synthesis of the economics, management, operations research, planning and educational literature on the application of mathematical programming models in educational planning are briefly summarized below:

1. Most applications of mathematical programming models in educational planning have been at the macroeconomic or national levels of educational planning in European, and less developed countries, where investment in education is viewed as a component in aggregate national investment. Several authors suggest that these models might be applied in the United States; however, few reports of this type of activity can be found.

2. Influence of mathematical programming in state and local planning are of more recent origin. At the school district level these models have been utilized to analyze important management considerations regarding noninstructional policies such as transportation, school desegregation, school menu planning and school location and size. These models have made no direct contribution toward analyzing the central tasks of instructional planning, nor have they been considered as a means to develop either a theory of educational planning or a systematic procedure to coordinate present long and short range planning efforts.

3. Development of mathematical programming models for school district planning, in most cases, is conducted in disciplines other than education, i.e., systems engineering, economics, business administration, industrial management and operations research. The value of the models found in the literature

could be greatly enhanced and made more general if educational researchers and school executives would assist model builders to interpret the realistic nature of their model assumptions in light of the organizational characteristics of schools.

4. Based on the identified need for more effective communication between school executives and operations research specialists as a first step toward improving the utility of mathematical models in future educational planning efforts, a set of guidelines should be developed to evaluate this interaction over time between decision makers and technical specialists as they move toward agreement on decision criteria, operational variables and organizational constraints in each phase of planning. The extent to which other public sector organizations have resolved various modeling and planning problems similar to those encountered in educational organizations should be identified and disseminated to educational planners.

Based on the review of applications, the following criteria in the form of questions should provide planners and managers with some insight to evaluate operations research models reported in the literature, and also to assess the utility of decision models that might be proposed in connection with some future planning or policy analysis in the educational as well as other public sectors.

1. What is the single system to be modeled?

2. Should a unique model be built for each subsystem?

3. Who are the decision-makers? What assumptions are made about the decision-maker who would use the model?

4. Who is responsible for the generation of alternatives? How are they developed and by what criteria are they compared?

5. What are the goals, overall objectives or targets involved? What is their purpose?

6. Are priorities or weights involved? What is their purpose?

7. Are performance and effectiveness involved? How are these concepts defined and how are they measured?

8. What is the pertinent time span for the construction of the model as well as for its implementation once it can be validated?

9. What supportive information systems are required for the model?

10. What are the controllable variables? (For which decision-makers?)

11. What are the uncontrollable variables? (For which decision-makers?)

12. Can multiple criteria be translated to a single figure of merit? Does the concept of optimization vanish without a single criterion?

13. How would you implement the model in its intended environment? Are costs of translating an ideal model to a workable model in the real world prohibitive?

14. How would you teach people to do the things that the model asks people to do?

The following recent quote from the American Association of School Administrator's Commission on Administrative Technology very accurately reflects the interest of many educational administrators and planners in the emerging trends toward investigating the utility of operations research models as a means to improve educational planning that will ultimately effect needed changes and improvements in educational organizations.

> NO MAN IS AN ISLAND--AND NO PROFESSION CAN REMAIN ISOLATED FROM THE FERMENT IN ITS ENVIRONMENT. TO REMAIN A VIABLE FORCE IN EDUCATION, ADMINISTRATORS MUST BE SENSITIVE TO NEW DEVELOPMENTS AND BE CAPABLE OF ADAPTING THE RELEVANT TECHNOLOGY OF THIS ERA TO THEIR TASKS.

This review represents one small step in this direction. The recent work of the AASA Commission on Administrative Technology has been published and can be found in Section Two of the references under the name Stephen J. Knezwich, the publication editor.

REFERENCES

I. Mathematical Programming & Educational Planning

Adelman, Irma. A Linear Programming Model of Educational Planning: A Case Study of Argentina. In Irma Adelman and Erick Thorbecke (eds.). The Theory and Design of Economic Development. Baltimore: Johns Hopkins Press, 1964.

Alper, Paul. Introduction to Control Concepts in Educational Planning. In Organization for Economic Cooperation and Development. Mathematical Models in Educational Planning. Paris: OECD, 1967.

Andrew, Gary M. Operations Analysis. Department of Management Science, University of Minnesota; May 14, 1970.

Balinsky, Warren L. Some Manpower Planning Models Based on Educational Attainment. Technical Memorandum No. 185. Department of Operations Research, Case Western Reserve University; June 1970.

Banghart, Frank W. Educational Systems Analysis. Toronto: Collier-Macmillan, 1969.

Bartholomew, D.J. A Mathematical Analysis of Structural Control in a Graded Manpower System. Paper P-3. Office of the Vice President-Planning and Analysis, University of California; December 1969.

Barton, Richard F. On Optimization in the American University. Texas Technical University; June 25, 1970.

Benard, Jean. General Optimization Model for the Economy and Education. In Organization for Economic Cooperation and Development. Mathematical Models in Educational Planning. Paris: OECD, 1967.

Bowles, Samuel S. The Efficient Allocation of Resources in Education. Quarterly Journal of Economics. 81:189-219, 1967.

_____. Planning Educational Systems for Economic Growth. Cambridge: Harvard University Press, 1969.

_____. Towards an Educational Production Function. In W. Lee Hansen (ed.). Education, Income, and Human Capital. A Report of the National Bureau of Economic Research. New York: Columbia University Press, 1970.

Bruno, James E. An Alternative to the Use of Simplistic Formulas for Determining State Resource Allocation in School Finance Programs. American Educational Research Journal. 6:479-514, 1969 (a).

_____. Using Linear Programming Salary Evaluation Models in Collective Bargaining Negotiations With Teacher Unions. Socio-Economic Planning Sciences. 3:1-12, 1969 (b).

_____. A Mathematical Programming Approach to School System Finance. Socio-Economic Planning Sciences. 3:1-12, 1969 (c).

_____. A Linear Programming Approach to Position-Salary Evaluation in School Personnel Administration. Research Memorandum. RAND Corporation. Santa Monica, California; February 1969 (d).

_____. The Function of Operations Research Specialists in Large Urban School Districts. IEEE Transactions on Systems Science and Cybernetics. Volume SSC-6:293-302, October 1970 (a).

_____. Design of Performance Contracts Which Maximize Net School District Utility. Working Paper. School of Education, University of California at Los Angeles, 1970 (b).

Clarke, S. and J. Surkis. An Operations Research Approach to Racial Desegregation of School Systems. Socio-Economic Planning Sciences. 1:259-272, 1968.

Clough, Donald J. Theoretical and Empirical Aspects of a Constrained Flow Model for Part of the Ontario Secondary School System. Working Paper No. 36. Department of Management Sciences. University of Waterloo, 1970.

_____. and William P. McReynolds. State Transition Model of an Educational System Incorporating a Constraint Theory of Supply and Demand. Ontario Journal of Educational Research. 9:1-18, 1966.

Clough, Donald J. et al. Mathematical Programming Models of a Quasi-Independent Subsystem of the Canadian Forces Manpower System. Working Paper No. 34. Department of Management Sciences. University of Waterloo, 1970.

Cohn, Elchanan. Economic Rationality in Secondary Schools. Planning & Changing. 1:166-174, 1970.

Conant, Eaton H. A Cost Effectiveness Study of Employment of Nonprofessional Teaching Aides in Public Schools. U.S. Department of Health, Education and Welfare. Office of Education Final Report. Project No. OE-8-0481, Institute of Industrial and Labor Relations, University of Oregon, 1971.

Copa, George M. Identifying Inputs Toward Production Function Applications in Education. Technical Report No. 4. Research Coordinating Unit for Vocational Education. University of Minnesota, 1971.

Corazzini, A.J. and E. Bartell. Problems of Programming: An Optimum Choice Between General and Vocational Education. Kyklos. 18:107-113, 1965.

Correa, Hector. The Economics of Human Resources. Amsterdam: North Holland Publishing Company, 1963.

_____. Quantity vs. Quality in Teacher Training. Comparative Education Review. 8:141-145, 1964.

_____. Optimum Choice Between General and Vocational Education. Kyklos. 18:700-704, 1965.

_____. Models and Mathematics in Educational Planning. In George F. Beriday and Joseph A. Laufwerys (eds.). The World Year-Book of Education 1967: Educational Planning. London: Evans Brothers Limited, 1967.

_____. Quantitative Methods of Educational Planning. Scranton: International Textbook Company, 1969.

Crandell, Robert H. A Constrained Choice Model for Student Housing. Management Science. 16:B-112-120, 1969.

Davis, Russell G. Planning Human Resource Development: Educational Models and Schemata. Chicago: Rand McNally, 1966.

_____. On the Development of Educational Models at Harvard CSED: An Algebraic History of Activity in One Small Place. In Richard H. Kraft (ed.). Education and Economic Growth. Educational Systems Development Center, The Florida State University, 1968.

Demski, J.S. Accounting System Structured on a Linear Programming Model. Accounting Review. 42:701-712, 1967.

Eastman, Charles M. and Kenneth O. Kortanek. Modeling School Facility Requirements in New Communities. Management Science. 16:B-784-799, 1970.

Fox, Karl A. et al. Formulation of Management Science Models for Selected Problems of College Administration. U.S. Department of Health, Education, and Welfare, Office of Education, final Report Contract No. OEC-3-068058, Iowa State University, 1967.

_____. and Jati K. Sengupta. The Specification of Econometric Models for Planning Educational Systems: An Appraisal of Alternative Approaches. Kyklos. 21:665-693, 1968.

Golladay, Frederick L. A Dynamic Linear Programming Model for Educational Planning with Application to Morocco. Doctoral Dissertation, Department of Economics, Northwestern University; August 1968.

Graves, Robert J. and Warren H. Thomas. A Classroom Location-Allocation Model for Campus Planning. Socio-Economic Planning Sciences. 5:191-204, 1971.

Handa, M.L. An Econometric Analysis of Educational Investment. Educational Planning Occasional Papers No. 2. Department of Educational Planning. The Ontario Institute for Studies in Education, 1969.

Harden, Warren R. and Mike T. Tcheng. Classroom Utilization by Linear Programming. Technical Paper. Office of Academic Planning and Institutional Research. Illinois State University, 1971.

Harding, Robert E. The Linear Programming Approach to Master Time Schedule Generation in Education. In A.G. Holtzman and W.R. Turkes. Optimal Scheduling in Educational Institutions. U.S. Department of Health, Education, and Welfare, Office of Education, Cooperative Research Project No. 1323, University of Pittsburgh, 1964.

Heckman, Leila B. and Howard M. Taylor. School Rezoning to Achieve Racial Balance: A Linear Programming Approach. Socio-Economic Planning Sciences. 3:127-133, 1969.

_____. Designing School Attendance Zones by Linear Programming. Department of Environmental Systems Engineering, Cornell University; January 1970.

Hoenack, Stephen A. The Efficient Allocation of Subsidies to College Students. The American Economic Review. 61:302-311, 1971.

Holtman, A.G. Linear Programming and the Value of an Input to a Local Public School System. Public Finance. 23:429-440, 1968.

Hopkins, Charles O. State-Wide System of Area Vocational-Technical Training Centers for Oklahoma. Doctoral Dissertation, Department of Agricultural Education, University of Oklahoma; May 1970 (a).

_____. State-Wide System of Area Vocational-Technical Training Centers for Oklahoma. Research Coordinating Unit, Oklahoma State University, 1970 (b).

Koenigsberg, Ernest. Mathematical Analysis Applied to School Attendance Areas. Socio-Economic Planning Sciences. 1:465-475, 1968.

Lachene, Rene. The Application of Operations Research to Educational Planning. In Organization for Economic Cooperation and Development. Efficiency in Resource Utilization in Education. Paris: OECD, 1969.

Lavasseur, Paul M. A Study of Inter-relationships Between Education, Manpower and Economy. Socio-Economic Planning Sciences. 2:269-295, 1969.

Lawrie, N.L. An Integer Linear Programming Model of a School Time-Tabling Problems. The Computer Journal. 12:307-316, 1969.

Lutz, Raymond P. et al. Taking the Heat Off the School Lunchroom. A paper presented at the Annual Conference of the American Institute of Industrial Engineers, 1968.

_____. A Systems Study of School Desegregation. Research Report R-70-2. School of Industrial Engineering, University of Oklahoma; October 1970.

Maki, Dennis. A Programming Approach to Manpower Planning. Industrial and Labor Review. 23:397-405, 1970.

Mann, Stuart H. Dynamic Management of Library Size. Operations Research, Volume 18, Supplement 2, B-149; Fall 1970.

McCamley, Francis P. Activity Analysis Models of Educational Institutions. Doctoral Dissertation, Department of Economics, Iowa State University, 1968.

McNamara, James F. A Mathematical Programming Model for the Efficient Allocation of Vocational Technical Education Funds. Harrisburg: Pennsylvania Department of Education, 1970.

_____. A Regional Planning Model for Occupational Education. Socio-Economic Planning Sciences. 5:317-399, 1971.

McReynolds, William P. A Model for the Ontario Educaticnal Systems. Educational Planning Occasional Papers No. 8. Department of Educational Planning. The Ontario Institute for Studies in Education, 1969.

Newton, Rita M. and Warren H. Thomas. Design of School Bus Routes by Computer. Socio-Economic Planning Sciences. 3:75-85, 1969.

Nordell, Lawrence P. A Dynamic Input-Output Model of the California Educational System. Doctoral Dissertation. University of California at Berkeley, 1967.

_____. A Linear Activity Analysis Model of Primary and Secondary Education. Internal Working Paper No. 35. Space Sciences Laboratory, University of California, Berkeley, California, 1968.

O'Brien, Richard J. Models for Planning the Location and Size of Urban Schools. Socio-Economic Planning Sciences. 2:141-153, 1969.

Organization for Economic Cooperation and Development. Econometric Models in Education: Some Applications. Paris: OECD, 1965.

_____. Mathematical Models in Educational Planning. Paris: OECD, 1967.

_____. Efficiency in Resource Utilization in Education. Paris: OECD, 1969.

_____. A Simulation Model of the Educational System. Technical Report of the Center for Educational Research and Innovation. Paris: OECD; March 1970.

Patz, A.L. Linear Programming Applied to Manpower Management. Industrial Management Review. 11:31-38, 1970.

Persons, Edgar, Gary W. Leske and George A. Copa. Development and Demonstration of Innovations in Adult Agriculture Education. U.S. Department of Health, Education, and Welfare. Office of Education Final Report. Project No. O.E. 7-0758. Department of Agricultural Education, University of Minnesota, 1970.

Plessner, Yakir et al. On the Allocation of Resources in a University Department. Metroeconomica. 20:256-271, 1968.

Ploughman, T. et al. An Assignment Program to Establish School Attendance Boundaries and Forecast Construction Needs. Socio-Economic Planning Sciences. 1:243-258, 1968.

Sanderson, Robert D. The Expansion of University Facilities to Accommodate Increasing Enrollments. Research Report No. 69-8. Office of the Vice President-Planning and Analysis, University of California, July 1969.

Schoeman, M. Class Scheduling Algorithm. In University Management Models. Project GUM, Phase III, Graduate School of Business, University of Texas at Austin, December 1969.

Seigel, Barry N. Towards a Theory of the Educational Firm. Technical Report. Center for the Advanced Study of Educational Administration, University of Oregon, 1966.

Sen, Subrata. Models of Course-Sectioning and Faculty Assignment. In University Management Model, Project GUM, Phase III, Graduate School of Business, University of Texas at Austin; December 1969.

Sengupta, Jati K. and Karl A. Fox. Optimization Techniques in Quantitative Economic Models. Amsterdam: North Holland Publishing Company, 1969.

Shapley, R.P. et al. A Transportation Program for Filling Idle Classrooms in Los Angeles. P-3 405. The RAND Corporation, Santa Monica, California; July 1966.

St. Louis, Larry and James F. McNamara. Economies of Scale for a State System of Public School Districts. Occasional Paper Series. Center for the Advanced Study of Educational Administration, Eugene, Oregon, 1971.

Stone, Richard. Demographic Accounting and Model-Building. Paris: Organization for Economic Cooperation and Development, 1971.

Swanson, Austin D. Administrative Accountability Through Cost-Effectiveness Analysis: A Proposal. In Lesley H. Browder, Jr. (ed.). Emerging Patterns of Administrative Accountability. Berkeley: McCutchan, 1971.

Taft, Martin I. and Arnold Reisman. Toward Better Curricula Through Computer Selected Sequencing of Subject Matter. Management Science. 13:926-945, 1967.

Tanner, Charles K. An Automated Simulation Vehicle for School Business Administration Accentuating Computerized Selective School Lunch Menu Planning. Doctoral Dissertation. Department of Educational Administration, The Florida State University, 1968.

Thomas, J. Alan. The Productive School: A Systems Analysis Approach to Educational Administration. New York: John Wiley and Sons, 1971.

Tracz, George S. An Overview of Cptimal Control Theory Applied to Educational Planning. A paper presented at the Annual Meeting of the American Educational Research Association; February 1969 (ERIC Document No. EA-0020257).

Turksen, Ismail B. and Albert G. Holzman. Micro Level Resource Allocation Models for Universities. Operations Research, Volume 18, Supplement 1, B-39; Spring 1970.

_____. Short Range Planning for Educational Management. Operations Research, Volume 18, Supplement 2, B-158; Fall 1970.

_____. Feasible Sets for a Class of Scheduling Problems. Department of Industrial Engineering, University of Toronto, 1970.

Van Dusseldorp, Ralph A., Duane E. Richardson and Walter J. Foley. Educational Decision-Making Through Operations Research. Boston: Allyn and Bacon, 1971.

Wasserman, William. Education Price and Quantity Indexes. Syracuse: Syracuse University Press, 1963.

Weathersby, George B. Educational Planning and Decision-Making: The Use of Decision and Control Analysis. Paper P-6. Office of the Vice President--Planning and Analysis, University of California; May 1970.

_____. The Allocation of Public Resources: A Decision and Control Analysis. Doctoral Thesis, Harvard University, 1970.

_____. and Milton C. Weinstein. A Structural Comparison of Analytical Models for University Planning. Paper P-12. Office of the Vice President--Planning and Analysis, University of California; August 1970.

Zemach, Rita. A State-Space Model for Resource Allocation in Higher Education. IEEE Transactions of Systems Science and Cybernetics. Volume SSC-4, No. 2, July 1968.

II. Educational Planning & Models

Abt. Clark C. A Game for Planning Education. In Werner Z. Hirsch. Inventing Education for the Future. San Francisco: Chandler Publishing Co., 1967.

Ackoff, Russell L. Toward Strategic Planning of Education. In Organization for Economic Cooperation and Development. Efficiency in Resource Utilization in Education. Paris: OECD, 1969.

Andrew, Gary M. and Ronald E. Moir. Information-Decision Systems in Education. Itasca: F.E. Peacock Publishers, 1970.

Arnold, Walter M. and James F. McNamara. A Systems Approach to State-Local Program Planning in Vocational Education. Socio-Economic Planning Sciences. 5:231-253, 1971.

Bailey, Stephen K. Educational Planning: Purposes and Power. Public Adminstration Review. 31:345-351, 1971.

Benson, Charles S. Economics and Education. Review of Educational Research. 37:96-102, 1967.

_____. Systematic Planning and American Education. Planning & Changing. 2:4-14, 1971.

Bereday, George Z. and Joseph A. Laufwerys (eds.). The World Yearbook of Education 1967: Educational Planning. London: Evans Brothers Limited, 1967.

Bowman, Mary J. A Response to Papers on Educational Planning. Comparative Education Review. 14:363-369, 1969.

Brookes, J.E. Operational Research in Educational Administration. Education and Urban Society. 3:7-40, 1970.

Burkhead, Jesse. Input and Output in Large-City High Schools. Syracuse: Syracuse University Press, 1967.

Campbell, Donald T. and Julian C. Stanley. Experimental and Quasi-Experimental Designs of Research. In N.L. Gage (ed.). Handbook of Research on Teaching. Chicago: Rand McNally, 1963.

Chirikos, Thomas N. and A.C. Wheeler. Concepts and Techniques of Educational Planning. Review of Educational Research. 38:264-276, 1968.

Cronbach, Lee J. and Patrick Suppes. Research for Tomorrow's Schools: Disciplined Inquiry for Education. New York: Macmillan, 1969.

Culbertson, Jack and Robin H. Farquhar. Content in Administrator Preparation. The University Council for Educational Administration Newsletter. 12:8-11; April 1971.

Dorfman, William. Principles and Techniques of Systems Analysis. In Ralph L. Spencer and Donald L. Walters (eds.). Systems Analysis Symposium Proceedings. Department of Educational Administration. Temple University, 1970.

Durstine, Richard M. In Quest of Useful Models for Educational Systems. Socio-Economic Planning Sciences. 2:417-437, 1969.

_____. Technical Trends in Educational Management: Opportunities and Hazards. Comparative Education Review. 14:327-334, 1970.

Dyer, Henry S. Can We Measure the Performance of Educational Systems? The Bulletin of the National Association of Secondary School Principals. 54:97-105, May 1970.

Furse, Bernarr S. and Lyle D. Wright. (eds.). Comprehensive Planning in State Education Agencies. Salt Lake City: Utah State Board of Education, 1968.

Government Studies Center. Education-Planning-Programming Budgeting System Procedures Manual for School Districts. Version 2, Model 1. Fels Institute, University of Pennsylvania; May 1969.

Hack, Walter G. et al. Educational Futurism 1985: Challenges for Schools and Their Administrators. Berkeley: McCutchan Publishing Company, 1971.

Harman, Willis W. Technology and Educational Policy Research. In Edgar L. Morphet and David L. Jesser (eds.). Designing Education for the Future. Volume 6. New York: Citation Press, 1969.

Hartley, Harry J. Limitations of Systems Analysis. Phi Delta Kappan. 50:515-519, 1969.

Hirsch, Werner Z. Inventing Education for the Future. San Francisco: Chandler, 1977.

Hufner, Klaus. Economics of Higher Education and Educational Planning: A Bibliography. Socio-Economic Planning Sciences. 2:25-101, 1968.

James, H. Thomas. The New Cult of Efficiency and Education. Pittsburgh: University of Pittsburgh Press, 1968.

Johns, Roe L. et al. (eds,). Dimensions of Educational Need. Gainsville, Florida: National Educational Finance Project, 1969.

_____. Planning to Finance Education. Gainsville, Florida: National Educational Finance Project, 1971.

Knezevich, Stephen J. (ed.). Administrative Technology and the School Executive. Washington, D.C.: American Association of School Administrators, 1969.

Kraft, Richard H. Manpower Planning and Its Role in the Age of Automation. Review of Educational Research. 40:495-510, 1970.

Levin, Henry M. The Effect of Different Levels of Expenditures on Educational Output. In Economic Factors Affecting the Financing of Education. National Educational Finance Project. Volume 2, 1970.

_____. A New Model of School Effectiveness. Research and Development Memorandum No. 63, Center for Research and Development in Teaching, Stanford University; May 1970.

_____. et al. School Achievement and Post-School Success: A Review. Review of Educational Research. 41:1-16, 1971.

Marien, Michael. Essential Reading for the Future of Education: A Selected and Critically Annotated Bibliography. Syracuse: Educational Policy Research Center, Syracuse University Research Corporation, 1970.

McLaughlin, James F. Application of Linear Programming to Urban Planning. Unpublished M.U.P. Thesis. University of Illinois, 1968.

McNamara, James F. A Systems Approach to Educational Planning. In Gordon F. Law (ed.). American Vocational Association Yearbook. 1971. Washington, D.C.: AVA, 1971.

_____. Operations Research and Educational Planning. Occasional Paper. Center for the Advanced Study of Educational Administration, University of Oregon, 1971.

_____. and Stephen J. Franchak. Planning Vocational Education Programs in Pennsylvania: Guidelines for the Use of Labor Market Information. Harrisburg : Pennsylvania Department of Education, 1970.

McNamara, James F. and Jay Smink. The Future Role of State Education Departments. Planning and Changing. 1:116-123, 1970.

Mood, Alexander M. The Operations Analysis Program of the U.S. Office of Education. In Werner Z. Hirsch (ed.). Inventing Education for the Future. San Francisco: Chandler Publishing Company, 1967.

_____. Analysis of the American Educational System. University of California at Irvine, 1969. (mimeo)

Morphet, Edgar L. et al. (eds.). Designing Education for the Future. Volumes 1-8. New York: Citation Press, 1969.

Morse, P.M. Library Effectiveness: A Systems Approach. M.I.T. Press, 1968.

Nystrand, Raphael O. and Frederick Bertolaet. Strategies for Allocating Human and Material Resources. Review of Educational Research. 37:448-468, 1967.

Ohm, Robert E. The School Administrator in 1985. In Walter G. Hack et al. Educational Futurism 1985. Berkeley: McCutchan Publishing Company, 1971.

Parnes, Herbert S. Forecasting Educational Needs for Economic Cooperation and Development. Paris: Organization for Economic Cooperation and Development, 1962.

Platt, William J. Research for Educational Planning: Notes on Emerging Needs. Paris: UNESCO International Institute for Educational Planning, 1970.

Restle, Frank. The Relevance of Mathematical Models for Education. In Ernest R. Hilgard (ed.). The Sixty-Third Yearbook of the Society for the Study of Education. Part 1, Theories of Learning and Instruction. Chicago: University of Chicago Press, 1964.

Sanders, Donald P. and Peter S. Barth. Education and Economic Development. Review of Educational Research. 38:213-230, 1968.

Shina, Bani K. et al. Toward Aggregate Models of Educational Systems. Socio-Economic Planning Sciences. 3:25-36, 1969.

Sisson, Roger L. Can We Model the Educaticnal Process? Socio-Economic Planning Sciences. 2:109-119, 1969.

_____. et al. The Project Concept in Planning, Programming, and Budgeting. Socio-Economic Planning Sciences. 4:239-261, 1970.

Solomon, Herbert. How Quantitative is Education? Socio-Economic Planning Sciences. 2:315-321, 1969.

Stephens, E. Robert. Functional Allocation in State Departments. Planning & Changing. 2:81-88, 1971.

St. John, Nancy H. Desegregation and Minority Group Information. Review of Educational Research. 40:111-134, 1970.

Stoller, David S. and William Dorfman (eds.). Proceedings of the Symposium on Operations Analysis of Education. Socio-Economic Planning Sciences. 2:103-520, 1969.

Temkin, Sanford. A Cost-Effectiveness Evaluation Approach to Improving Resource Allocations for School Systems. Doctoral Dissertation, University of Pennsylvania, 1969.

_____. An Evaluation of Comprehensive Planning Literature With An Annotated Bibliography. Philadelphia: Research for Better Schools, 1970.

_____. and James F. McNamara. A Comprehensive Planning Model for School Districts: Decision Rules and Implementation Strategies. Technical Paper. Research for Better Schools, Philadelphia, Pennsylvania, 1971.

Thomas, J. Alan. An Economic Approach to Systems Analysis. A paper presented at the Annual Meeting of the American Educational Research Association; February 1969.

U.S. Department of Health, Education, and Welfare. Vocational Education and Occupations. OE-80061. Washington, D.C.: U.S. Government Printing Office; July 1969.

_____. Educational Research and Development in the United States. OE-12049. Washington, D.C.: U.S. Government Printing Office, 1970.

Venn, Grant. Man, Education, and Manpower. Washington, D.C.: The American Association of School Administrators, 1970.

Weitz, Harold. An Assessment of the Contributions of Operations Research to Educational Planning. Technical Paper No. XVIG. 4. IBM. Yorktown Heights, New York, 1969.

Williams, Gareth L. Toward a National Educational Planning Model. Socio-Economic Planning Sciences, 2:251-261, 1969.

Witmer, David R. Economic Benefits of College Education. Review of Educational Research. 40:511-524, 1970.

Wolvek, Joe. A Comprehensive Planning Process for the State Department of Public Instruction. Des Moines: Iowa Department of Public Instruction, 1968.

III. Methodology & Operations Research

Ackoff, Russell L. Scientific Method: Optimizing Applied Research Decisions. New York: John Wiley and Sons, 1962.

_____. and Patrick Rivett. A Manager's Guide to Operations Research. New York: John Wiley and Sons, 1962.

Aronofsky, Julius S. Progress in Operations Research. Volume III. Relationship Between Operations Research and the Computer. New York: John Wiley and Sons, 1969.

Baumol, William J. Economic Theory and Operations Analysis. Second Edition. Englewood Cliffs: Prentice-Hall, 1965.

Bellman, Robert. Dynamic Programming. Princeton: Princeton University Press, 1957.

Blumstein, Alfred, Murray Kanrass and Armand B. Weiss (eds.). Systems Analysis for Social Problems. Washington, D.C.: Washington Operations Research Council, 1970.

Camina, Margaret. Plan-Design Models: A Review. Town Planning Review. 40:119-130, 1969.

Churchman, C. West, Russell A. Ackoff and E. Leonard Arnoff. Introduction to Operations Research. New York: John Wiley and Sons, 1957.

Coleman, James S. Introduction to Mathematical Sociology. New York: The Free Press of Glencoe, 1964.

Cooper, Leon and David Steinberg. Introduction to Methods of Optimization. Philadelphia: W.B. Saunders Company, 1970.

Dantzig, George B. Linear Programming and Extensions. Princeton: Princeton University Press, 1963.

Dorfman, Robert. Mathematical or "Linear" Programming: A Nonmathematical Exposition. The American Economic Review. 93:297-325, 1953.

Driebeek, Norman J. Applied Linear Programming. Reading: Addison-Wesley, 1969.

Ferrero Di Roccaferrera, Giuseppe M. Sensitivity Analysis and the Managerial Decision Process. Department of Management Science, Syracuse University; October 1970.

Gass, Saul L. An Illustrated Guide to Linear Programming. New York: McGraw-Hill, 1970.

Hadley, George. Nonlinear and Dynamic Programming. Reading: Addison-Wesley Publishing Company, 1964.

Harris, Britton. The City of the Future: The Problem of Optimal Design. Papers of the Regional Science Association. 19:185-195, 1967.

Henderson, Alexander and Robert Schlaifer. Mathematical Programming: Better Information for Better Decisions. Harvard Business Review. May-June 1954:73-100.

Isard, Walter. Methods of Regional Analysis. Cambridge: M.I. T. Press, 1960.

Kruskal, William (ed.). Mathematical Sciences and the Social Sciences. Englewood Cliffs: Prentice-Hall, 1970.

Lee, C. Models in Planning--Some Observations and Reservations. Planning Outlook. 8:9-15, Spring 1970.

Malinvaud, E. and M.O. Bacharach (eds.). Activity Analysis in the Theory of Growth and Planning. New York: St. Martin's Press, 1967.

Massey, Doreen B. and Martin Cordey-Hayes. The Use of Models in Structure Planning. Town Planning Review. 42:28-44, 1971.

Mertins, Herman and Bertram M. Gross (eds.). Symposium on Changing Styles of Planning in Post-Industrial America. Public Administration Review. 31:253-404, 1971.

Metzger, Robert W. Elementary Mathematical Programming. New York: John Wiley and Sons, 1958.

Nemhauser, George L. Introduction to Dynamic Programming. New York: John Wiley and Sons, 1967.

Olson, Mancur. An Analytic Framework for Social Reporting and Policy Analysis. Annuals of the American Academy of Political and Social Science. 38:112-126, 1970.

Pitkanen, Eero. Goal Programming and Operational Objectives in Public Administration. Swedish Journal of Economics. 72:207-214, 1970.

Rappaport, A. Integer Programming and Managerial Analysis. Accounting Review. 44:297-299, 1969.

Sengupta, Jati K. The Stability of Truncated Solutions in Stochastic Linear Programming. Econometrics. 34:77-104, 1966.

Shelly, Maynard W. and Glen L. Byran (eds.). Human Judgment and Optimality. New York: John Wiley and Sons, 1964.

Spiegelman, Robert G. Activity Analysis Models in Regional Development. Regional Science Association Papers and Proceedings. Volume II, 1963.

Stone, Richard. Consistent Projections in Multi-Sector Models. In E. Malinvaud and M. Bacharach (eds.). Activity Analysis in the Theory of Growth and Planning. New York: St. Martin's Press, 1967.

Stuart, Darwin G. Urban Improvement Programming Models. Socio-Economic Planning Sciences. 4:217-238, 1970.

Thiel, Henry. Economic Forecasts and Policy. Amsterdam, Netherlands: North-Holland Publishing Company, 1962.

Thierauf, Robert J. Decision-Making Through Operations Research. New York: John Wiley and Sons, 1970.

Thompson, James D. Organization in Action. New York: McGraw-Hill, 1967.

Wegner, P. Relations Between Multivariate Statistics and Mathematical Programming. Applied Statistics. 12:146-150, 1963.

Wilson, A.G. Models in Urban Planning: A Synoptic Review of Recent Literature. Urban Studies. 5:249-276, 1968.

Zellner, A. Linear Regression With Inequality Constraints on the Co-efficients: An Application of Quadratic Programming and Linear Decision Rules. Report 6109. International Center for Management Science. Netherland School of Economics, 1961.

_____. Decision Rules for Economic Forecasting. Econometrics. 31:111-131, 1963.

COUNCIL OF PLANNING LIBRARIANS Exchange Bibliography #271

APPLICATIONS OF MATHEMATICAL PROGRAMMING MODELS

IN EDUCATIONAL PLANNING: AN OVERVIEW

AND SELECTED BIBLIOGRAPHY

Additional copies available from:

Council of Planning Librarians
Post Office Box 229
Monticello, Illinois 61856

for $2.00